

SECTION M.16 TRAFFIC CONTROL SIGNALS

M.16.01--General Requirements: Where reference is made to certain manufacturers' material or products, it is not the intent to preclude the use of others, but rather to establish minimum acceptable design standards. The Contractor may substitute material and products of other manufacturers, provided they meet the minimum design standards and are approved by the Engineer.

M.16.02--Vacant:

M.16.03--Pedestals: The materials for this work shall conform to the following requirements:

1--Vacant

2--Aluminum Pedestals:

(a) Shaft: The shaft shall be made of ASTM B 210 Grade 6063-T6 or ASTM B 221 Grade 6005-T5 aluminum alloy and shall be either a seamless tapered tube with a 150 mm outside diameter at the base and a 115 mm outside diameter at the top, or a seamless straight tube with a 115 mm outside diameter. The height of the pedestal shall be as required by the item. The shaft shall have a minimum wall thickness of 3.2 mm and shall be devoid of welding except at the base. The shaft shall be satin brush finished and each shaft shall be individually protected from scratches, dents and abrasions during handling and shipping.

(b) Base: The base shall be a permanent mold casting of 356 aluminum alloy conforming to ASTM B 108 and shall be of the dimensions shown on the plans. The tapered shaft shall be secured to the base by means of a circumferential fillet weld on the inside of the base top, and the straight shaft shall be secured by means of threads and machine screws, which when set, shall be flush with the base top. The base shall be provided with a cast aluminum door with dimensions shown on the plans which shall be held in place by an approved locking device. Each base shall be provided with a grounding stud. All hardware used on the pedestal shall be 304 stainless steel conforming to ASTM A-276.

M.16.04--Poles: The materials for this work shall conform to the following requirements:

1--Steel Poles:

(a) Round Continuously Tapered Shaft: The continuously tapered shaft must have a maximum of two longitudinal continuous arc welds. No intermediate horizontal joints or welds will be allowed. Poles shall have a uniform wall thickness that tapers uniformly. All cross sectional shapes will be allowed, but multisided poles are required to be equilateral with a minimum of 8 sides. The shaft diameter must decrease from the butt end at the rate of not less than 6 and not more than 12 mm/m of length. Laminated pole designs (e.g. two-ply pole shafts) will not be permitted.

The shaft shall be placed under sufficient pressure to flatten the weld and increase the physical characteristics to a minimum guaranteed yield strength of 331 MPa.

(b) Round Step Tapered Shaft: Round step tapered shafts shall be fabricated from round pipe sections with a maximum of one longitudinal seam. Horizontal seams must be joined by a hot-swaged shrink fit and continuously seal welded to prevent the entrance of water.

The shaft diameter must decrease from the butt end at the rate of not less than 6 and not more than 12 mm/m of length. This is accomplished through the use of decreasing diameter round pipe sections.

(c) Base: The base shall telescope the shaft and shall have two continuous transverse arc welds, one being on the inside of the base at the end of the shaft and the other weld on the outside at the top of the base. The welded construction shall develop the full strength of the adjacent section resistant to bending action.

The anchor base shall have four holes to receive the anchor bolts and four holes directly behind each anchor bolt hole for ventilation. The anchor bolt holes shall be 9.5 mm larger than the diameter of the anchor bolt.

(d) Pole Size: The traffic signal span pole shall have the yield strength, bolt circle, and length indicated on the plans.

(e) Span Clamp: The span clamp shall be made of steel capable of supporting a minimum load of 53.5 kN without sustaining permanent distortion. There shall be one span clamp per span wire attachment. Additional span clamps shall be provided as required.

(f) "J" Hook: The "J" Hook shall be affixed inside the top of the pole for handling and cable support.

(g) Luminaire Bracket: The type and spread of the luminaire bracket shall be as indicated in the details on the plans. The bracket shall be the single-arm-type for brackets 2.5 m and under in length and the truss-type for brackets 3 m and longer in length unless otherwise specified.

The truss-type shall consist of an upper and lower galvanized steel member securely joined by means of a vertical strut steel pipe without ornamental steel scroll.

The brackets shall be attached to the pole by means of a bolted clamp so that the angle for the arm may be adjusted in the field.

(h) Handhole: A steel handhole reinforcing frame a minimum size 100 by 165 mm, complete with removable cover, shall be welded to the shaft approximately 380 mm above the base. The cover shall be fabricated from galvanized steel.

(i) Wire Entrance Fitting: All steel span poles shall include wire entrance fittings. The number and size of the wire entrance fittings shall be as required to accept the cables shown on the plans. A neutral bracket and 25 mm entrance fitting shall be provided for service cables. A separate fitting will also be required for any communications cable. These couplings will be continuously welded to the pole at a 45 degree angle to the pole shaft.

(j) Anchor Bolt Covers: Four removable galvanized ferrous or aluminum anchor bolt covers that attach to the pole base shall be provided. The anchor bolt covers shall be attached by a tapped hole and screw to either the pole base or pole shaft. The covers shall fit snugly and have a neat appearance.

(k) Electrical Ground: Each span pole shall be electrically grounded to a ground rod. The span pole will be connected to the ground rod by a #8 AWG copper wire. The wire shall be connected to the pole by a stainless steel bolt and to the ground rod by a square head bolt clamp, conforming with the NEC.

(l) Identification: Span pole information (as described below) shall be included on the poles in the form of a stamp on the top of the base plate, or an aluminum tag riveted to the base of the pole or to the pole shaft below the handhole.

- (a) Minimum load at yield
- (b) Name of manufacturer
- (c) Year of manufacture
- (d) Height of the pole

(m) Fabrication: The steel pole shall be fabricated in conformance with the current AASHTO specifications for highway signs, luminaires, and traffic signals. The pole manufacturer shall include a statement on his materials certificates stating that the welding design and fabrication is in accordance with the AWS Structural Welding Code D1.1-Steel.

(n) Finish: The steel span pole (shaft and base and luminaire bracket) shall be hot-dip galvanized, conforming to the requirements of ASTM A123. Pole cap, bolt covers, handhole covers, span clamps, bolts, screws, washers, nuts, and wire entrance fittings shall be galvanized as per ASTM A153.

2--Wood Poles:

(a) Pole: Wood poles shall conform to the requirements of ANSI 05.1 and AWWA C-1 and AWWA C-4. The pole shall be class 3 and of sufficient length to obtain the necessary height of the signals above the roadway or the mounting height of luminaires above the roadway.

The poles shall be trimmed by machine without materially changing their size or taper. Poles shall be branded on the face, have a flat roof, and shall be aluminum tagged on the butt in accordance with ANSI 05.1. The arrangement and order of the code letters and figures shall be as the following example indicates.

PTC	Supplier's code or trademark
F-78	Plant location and year of treatment
SPC	Species and preservative code
3-35	Class and size

The dimensions for the poles required shall not be more than 75 mm shorter or 150 mm longer than the nominal length. The length shall be measured between the extreme ends of the pole. The minimum bottom circumference shall be measured at a point 2 m from the butt and the minimum dimensions for the poles shall be as follows:

Length	Bottom Circumference	Top Circumference
9.1 m	813 mm	584 mm
10.7 m	864 mm	584 mm
12.2 m	914 mm	584 mm
13.7 m	953 mm	584 mm
15.3 m	990 mm	584 mm

The preservative treatment of the pole shall be done in accordance with the Standard Specification for Preservatives and Pressure Treatment Process for Timber, AASHTO M 133. The following named preservatives are acceptable. The properties shall be those set forth in the referenced AWWA standards:

1. Creosote	AWPA	P-1
2. Pentachlorophenol	AWPA	P-8
3. Chromated Copper Arsenate —Type C	AWPA	P-5

(b) Anchor: The anchor to be used for guying the pole shall be a four-way sliding plate as indicated on the plans.

(c) Anchor Rod: The anchor rod to be used for guying the pole shall be of drop steel and shall be hot-dip galvanized.

It shall be as indicated on the plans.

It shall conform to one of types as listed in the special provisions.

(d) Anchor Guy Strand Wire: The anchor guy strand wire shall be 10 mm 7-wire strand, supplied with a zinc coating by the hot-dip galvanized process in accordance with ASTM A 475 for zinc-coated steel wire strand, and shall have a minimum breaking strength of strand of 50 kN for utilities grade.

(e) Guy Wire Protector: The guy wire protector to be used shall be the half-round type either fabricated from a minimum of 16 gauge hot-dip galvanized steel or from high impact 13454A Polyvinyl Chloride ASTM 1784 compound standard. It shall have hot-dip galvanized steel clamps. The steel clamps shall conform to ASTM requirements A36 for steel and A123 for galvanization. There will be 3 clamps which will accept any strand size 6.4 mm diameter and larger, and any anchor rod up to 25 mm diameter.

M.16.05--Mast Arm Assembly: The materials for this work shall conform to the following requirements:

1--Aluminum:

(a) Shaft: The shaft shall be 6005-T5 Aluminum Alloy as specified by ASTM B-221 or approved equal, and shall be a seamless tube tapered by cold working. The shaft wall thickness, length and tube diameters shall be as indicated on the Plans. The shaft shall have a satin brush finish and shall be suitably protected during handling and shipping.

(b) Arm: The arm shall be of tapered elliptical truss-type design. The arm shall consist of an upper and lower member joined by vertical braces and clamps of 356 Cast Aluminum Alloy conforming to ASTM B 108 for attachment to the Shaft. All necessary fittings and adjustable signal mounting assemblies required for attachment of the signal heads shall be included with the arm. The arms and struts shall be fabricated of 6005-T5 wrought aluminum alloy as specified by ASTM B-221 or approved equal. The arm shall be formed to dimensions as shown on the plans. The wall thickness shall be as shown on the plans. All vertical braces shall be 60 mm O.D. having a 3.6 mm wall thickness and ellipsized to a cross-section of 76 mm X 44.5 mm. The clamp castings shall withstand the design load of the arm assembly as shown on the shop drawings.

(c) Shoe Base: The shoe base shall be 356 cast aluminum, conforming to ASTM B 108 of adequate shape and size to develop the full strength of the adjacent shaft section. The base shall be secured to the lower end of the shaft by two continuous welds. The base shall telescope the shaft, and one weld shall be on the inside of the base at the end of the shaft and the other weld shall be on the outside at the top of the base. The base shall be provided with four holes for mounting on the 406 mm bolt circle and four cast aluminum bolt covers which shall be attached to the base by means of stainless steel screws.

(d) Transformer Base: The transformer base shall be a permanent mold casting of 356-T5 aluminum alloy conforming to ASTM B 108 and shall be of sufficient size to withstand the full design load of the shaft. The transformer base shall have a door of dimensions shown on plans attached to the base by means of cast lugs at the bottom and a stainless steel socket head cap screw with a wrought aluminum latch at the top. The bottom of the base shall have provision for anchorage at the corners to accept four anchor bolts.

(e) Welding: Welding of aluminum shall conform to the AASHTO "Specifications for the Design and Construction of Structural Supports for Highway Luminaires," Section 10--Fabrication of Welded Aluminum Structures.

2--Steel:

(a) Shaft: The shaft shall be made from one length of sheet steel not less than the gauge specified. There shall be a maximum of two longitudinal continuous arc welds. There shall be no intermediate horizontal joint or weld. The length of sheet steel shall be formed into a continuously tapered shaft, having a taper of approximately 12 mm/m. The arm sizes are as shown on the Plans.

After the welding and cold-rolling, the shaft shall be placed under sufficient pressure to flatten the weld and increase the physical characteristics of the shaft so the metal will have a minimum yield of 331 MPa. Cross-sectional shapes other than round will be allowed. A steel handhole reinforcing frame a minimum size 100 mm by 165 mm, complete with removable cover, shall be welded to the shaft approximately 380 mm above the base. The cover shall be galvanized steel. There shall be a 12.5 mm tapped hole near the base of the shaft for the grounding bolt.

A round step tapered shaft will also be acceptable. The shaft shall be fabricated from round pipe sections with not more than one longitudinal seam, joined by a hot-swaged shrink fit, continuously seal-welded to prevent the entrance of water. Stepped round shafts must decrease in diameter from the butt end at the rate of not less than 6 and not more than 12

mm/m of length by use of decreasing diameter round pipe sections. The minimum yield strength of the material shall be 331 MPa.

A flange plate, a minimum of one and a 32 mm thick, shall be welded to the pole near the top supported by side plates tangent to the pole and gusset plates, both top and bottom. The flange plate shall have a 64 mm diameter wiring hole and four tapped holes for 32 mm high tensile bolts.

A device shall be provided near the top, inside of the pole, to relieve the strain on the cable feeding the signals. The pole cap shall be secured by means of set screws.

Where shown on the plan, there shall be provided a steel tapered luminaire bracket. The bracket shall be the single arm type for brackets 2.4 m and under in length and truss type for brackets 3 m and longer. The truss type shall consist of an upper and lower member securely joined by means of a vertical strut. The upper and lower members shall be 50 mm I.P.S. steel pipe without ornamental steel scroll. The length of the bracket shall be as shown on the plans.

(b) Anchor Base: A one-piece steel anchor base of the adequate strength, shape and size shall be secured to the lower end of the shaft by two continuous electric arc welds. The base shall telescope the shaft, and one weld shall be on the inside of the base at the end of the shaft, while the other weld shall be on the outside at the top of the base. The two welds shall be approximately 50 mm apart, and the design shall be such that the welded connection shall develop the full strength of the adjacent shaft section to resist bending action.

The base shall be provided with four holes to receive the anchor bolts, and four tapped holes for attaching the anchor bolt covers.

(c) Mast Arm: The mast arm may be made of one length or two lengths of steel. There shall be a maximum of two longitudinal continuous arc welds. The length of sheet steel shall be formed into a continuous taper shaft having a taper of approximately 12 mm/m. After the welding and cold-rolling, the mast arm shall be placed under sufficient pressure to flatten the weld and increase its physical characteristics so that the metal will have a guaranteed minimum yield strength of 331 MPa.

A flange plate, 32 mm thick, shall telescope the large end of the mast and be welded by two continuous electric arc welds. One weld shall be on the outside of the plate, adjacent to the shaft, and the other weld on the inside at the end of the tubular cross-section. The flange plate shall have four holes for the 32 mm high tensile bolts, which shall match the four tapped holes in the mounting plate on the pole.

Mast arms for step tapered shafts may be two-piece construction with a telescoping joint secured by a thru-bolt and lock nut. Arms less than 10.7 m in length need not be tapered. The arm shall be not less than the gauge specified. The minimum yield strength of the material shall be 331 MPa.

Each mast arm shall be drilled in the field on the bottom surface for wire outlet holes and signals positioned at the location indicated on the signal plans. Rubber grommets shall be provided and installed by the Contractor at each field drilled hole to protect the signal cables from chafing.

A steel removable cap shall be attached to the end of the arm by a set screw. For each required signal, a clamp and clevis with 19 mm diameter hole shall be furnished.

(d) Finish: The steel mast arm assembly and luminaire bracket shall be hot-dip galvanized, conforming to the requirements of ASTM-A123 unless otherwise specified. Pole Cap, bolt covers, handhole covers, bolts, washers, nuts and screws shall be galvanized, conforming to the requirements of ASTM A153.

(e) Fabrication: The steel Mast Arm Assembly shall be fabricated in conformance with the current AASHTO specifications for highway signs, luminaires, and traffic signals. The manufacturer shall include a statement on his materials certificates stating that the welding design and fabrication is in accordance with the AWS Structural Welding Code D1.-1-Steel.

3--Identification: Mast Arm identification (as described below) shall be included in the form of a stamp on the top of the base plate, or an aluminum tag riveted to the base of the shaft below the handhole.

- (a) Maximum equivalent end load (mass and area)
- (b) Name of manufacturer
- (c) Year of manufacture
- (d) Arm length

M.16.06--Traffic Signals: The materials for this work shall conform to the following requirements:

1--General: The components of a traffic control signal head assembly or unit shall conform to the I.T.E. requirements for Adjustable Face Traffic Control Signal Head Standards Technical Report of the latest issue.

2--Traffic Control Signals: Each signal head shall be of the adjustable, vertical type with the number and type of sections and lamps as shown on the plans, shall provide a light indication in one direction only; and shall be adjustable through 360 degrees without the removal from the mounting bracket; and shall be mounted at the locations, and in the manner as shown on the plans. Unless otherwise indicated on the plans, all signal heads shall be standard and shall contain three lights arranged as follows: Red-top; Amber-center; Green-bottom. All signal heads in this contract shall be of the same make and type.

3--Housing: The signal head housing shall be made of a die-cast aluminum alloy per ASTM B 85. The signal head housing shall consist of an assembly of three or more separate sections, expandable type, for vertical mounting, substantially secured together in a watertight and rigid manner to form a unit of pleasing appearance.

Each section shall house an individual optical unit. The signal head shall be so designed that sections may be added or removed from the head assembly by the use of simple tools.

The housing shall be a die casting, rigidly constructed with a smooth outer surface. There shall be a round opening in the top and bottom of each head to receive a 38 mm supporting pipe frame. The portion of the housing section around the opening shall be reinforced and serrated so that serrated fittings may be used to secure the housing. The top and bottom of the housing shall include such other openings as are necessary to accommodate fastening devices to hold sections together, and such openings shall not permit entrance of foreign particles. Each section shall be positively indexed with respect to an adjacent section to prevent misalignment. Each housing section shall be equipped with a door with an opening and fittings for the optical unit and visor. The door shall be arranged for easy access to the optical unit components and wiring. It shall be hinged on its left side so that the door cannot be removed without the use of tools at two points and shall be provided with a simple, positive-acting door locking device made from stainless steel to assure tight closure. The door or housing shall be grooved to receive a neoprene gasket to provide a resilient seal between the door and housing. The body and door of each housing section shall be of die-cast aluminum alloy and shall be clean, smooth, and free from flaw, crack, blow holes, or other imperfections. The door locking device and visor fastening screws shall be made of stainless steel. All other screws, nuts, washers, hinge pins, latch parts, clips and parts used in the assembly of the signal housing shall be made of either naval brass, everdur, phosphor bronze, stainless steel or approved equal.

4--Brackets: The signal heads, except for post-top mounting, shall be supported by mounting brackets consisting of assemblies of 38 mm, standard, iron pipe and malleable iron fittings. All members shall be plumb and level, symmetrically arranged, and securely made up. Construction shall be such that all conductors are concealed within poles and assembly.

Each section of the housing shall be provided with a removable cap visor of not less than #16 B & S Gage Aluminum. The cap visor shall be painted a flat black on the inside to prevent reflection, and must also eliminate sun-phantom. The visor shall fit snugly against the door and shall not permit any perceptible filtration of light between the door and the visor.

A terminal block shall be mounted inside of the back of the housing in the top section. The terminal blocks shall have sufficient studs with separate screws to terminate all field wires and lamp wires independently to the block.

When indicated on the plans, a backplate of dimensions, as shown on the plans, constructed of 3003H 14 aluminum alloy sheet 1.3 mm minimum thickness conforming to ASTM B-209 shall be attached to the signal head housing. The backplate shall be painted a flat black on both sides.

5--Optical Unit: The optical unit shall consist of a lens, reflector, reflector frame, and socket and traffic signal lamp of the size shown on the plans. Other necessary equipment shall be designed to give clearly visible signal indications within an angle of at least 45 degrees to the traffic to be controlled and from 3 m to 91.5 m, under all light and atmospheric conditions except dense fog; and shall be of such design as to eliminate sun-phantom effects. The optical unit shall be readily accessible for maintenance.

Lenses shall be of the color indicated, circular in shape, with a visible diameter of 203 mm, unless otherwise noted on the plans, except that all arrow lenses shall have a visible diameter of 305 mm. Except where indicated on the plans, the use of adapters to achieve 305 mm indications will not be allowed. Lenses shall be of such design to give an outward and downward distribution of light with a minimum above the horizontal. Arrow lenses shall conform in design to ITE standards and shall be of a green light diffusing nature, giving uniform distribution of illumination on all areas of the lens. The field for arrow lenses shall consist of a black ceramic compound, baked or fired into the glass.

Each lens shall be polycarbonate capable of withstanding continuous illumination of a standard traffic signal lamp without thermal distortion (100 Watt - 203 mm lens) (150 Watt - 305 mm lens). The lens shall be 4.8 mm to 8 mm in thickness, smooth on the outside surface, annealed to relieve internal stresses and of high illumination transmission. An air-cured neoprene lens gasket shall be provided between the lens and the signal door and between the lens and the reflector ring. The two ends of the lens gasket shall be joined together by vulcanizing or other approved method. Each lens shall have the word "Top" marked on its flange to indicate proper positioning of the lens in the door, together with the trademark of the lens manufacturer and label indicating conformance with the specifications set forth in the ITE standards. The lens and its gasket shall provide water-tight and dust-tight construction. The gasket shall be molded, heat-resistant neoprene.

The reflector shall be made of specular Alzak aluminum, the thickness of the anodic coating to a minimum of 2.5 μ m, or its equivalent, spun or punched from metal not less than 0.6 mm thick, equipped with a bead or flange on the outer edge to stiffen the reflector and insure its being held true to shape. The reflecting surface shall be totally free of flaws, scratches, defacements or mechanical distortion.

An opening in the back of the reflector for the lamp holder shall be so constructed that there will be no dark spots cast on the lens. The reflector shall be of the pressure type, free floating and must insure full seal against the lens gasket. The reflector frame shall be of die-cast aluminum constructed completely around the reflector, and arranged to assure maintaining proper positioning of the reflector with respect to the lens under normal operating conditions. Proper position shall be maintained after opening and closing the unit for lamp replacement and other maintenance functions. A dust-tight gasket shall be provided between the reflector and the reflector-holding ring. If this gasket is of neoprene, it shall be made continuous by vulcanizing ends together or by another process approved by the Engineer. Additional dust-tight gasketing shall be provided between the lamp holder and the reflector.

6--Lamp Socket: The lamp socket shall be so designed that the tip or center contact shall retain its spring action and shall not twist or turn when lamps are installed. The ring or outer contact shall be securely fastened to the receptacle base so that it will not become loose, break out, or turn when replacing lamps. The lamp socket shall be mounted so that when a lamp is properly inserted and adjusted it shall retain that position. The lamp socket shall be made of heat-resistant material designed to hold a traffic signal lamp of the wattage indicated on the plans, and shall be of the vibration-proof type, weatherproof molded construction, immune to the operating temperatures of the unit and substantially supported, independent of the reflector. Each lamp socket shall be the adjustable type and shall be wired with two leads using a minimum size of #18 AWG, 600 volt, 115 degree C stranded wire not less than 1 m long. This wire shall be marked in accordance with Article 310-11 of the latest edition of the NEC. The sockets shall be so wired that a white lead will be connected to the shell of the socket and a black lead to the bottom or end terminal of the socket.

All lamps shall have indelibly etched thereon the name of the manufacturer, the ratings in watts for which the lamp was designed and the operating voltage of the lamp. Each lamp shall have the beam candela specifications of the ITE.

The lamps shall operate at 67 or 69 watts as the case may be at plus or minus 4% at rated voltage. The lamps shall have a voltage rating of 125 volts and the initial lumen rating of the 67 Watt lamp shall not be less than 618 and the 69 Watt lamp not less than 630.

The bulb designations shall be AT-21 or A-21 for the 67 Watt and A-21 for the 69 Watt. The 67 Watt lamps shall have a maximum over all length of 117 mm and a light center of 62 mm. The 69 Watt lamps shall have a maximum over all length of 113 mm and a light center of 76 mm. All lamps shall have a fuse wire within their structure to prevent damage to lamp circuitry or receptacle and they shall also have an aluminum reflector disc incorporated within the bulbs to assist light control.

The base of the lamps shall be medium, made of brass, and shall have the base stamped or printed with "Scratch Out" letters and numerals which indicate 12 months of the year and at least 4 indications for years. This is for the purpose of maintaining control for relamping.

The burning position shall be base down or horizontal and the lamps shall have a rated life of 8,000 hours of use guaranteed by the manufacturer.

The 67 Watt lamps shall be installed in traffic signals with 203 mm lenses. The 69 Watt lamps shall be installed in the traffic signals with 305 mm lenses.

7--Mountings: All signal heads shall be equipped with positive locking devices and fittings designed to prevent the heads from turning due to external forces. Number 2 Permatex or approved equal shall be used at all points where lock nuts and washers are used in assembling heads.

8--Dual Color Fiber Optic Section: When called for on the plans, signals shall be provided which display alternate legends, consisting of either a green or amber directional arrow. The arrows shall be illuminated by the use of fiberoptics and shall be clearly legible and visible, at full intensity, anywhere within a 50 degree cone, centered about the optical axis.

Any combination of colors shall be available by changing color filters installed in the unit, i.e., a signal supplied to display both a green and amber arrow could be field modified to display red and green arrows without the necessity of removing the signal from the case.

One lamp, type ENL, shall be used for each message. These lamps shall be operated between 10.5 and 10.8 volts. Average lamp life shall be not less than 8,000 hours. Field data, laboratory data and manufacturing specifications shall be supplied to substantiate lamp life.

Non-lensed, fully randomized bundles shall be used to provide a 50 degree, total-viewing angle. Nineteen (19) individual enlarged diameter bundles shall be used to form the arrow legend. The same bundles shall be used to display either message.

In order to help balance the intensity between colors, provisions shall be made in the construction of the signal to supply approximately 50% more light to the green arrow indication than supplied to the amber arrow indication.

Transformers shall be used to reduce the incoming 120 volts AC to 10.8 volts AC. The transformer shall have Class A insulation and shall be rated at 48.5 volt amps.

Power consumption of the dual color arrow shall be less than 50 Watts.

A separate transformer and bulb shall be used for each color to allow connection with the controller wiring and conflict monitors. Identical lamp types shall be used for each message.

Fiber optics shall be glass fiber bundles assembled on flat black matrix panels with mechanical protection for the assembly. The glass fibers at the input and output ends shall be ground smooth and optically polished for maximum light transmission. Matrix panel to have flat black non-reflective finish.

To eliminate long term condensation effects of thermal cycling, individual fiberoptic bundles shall not be jacketed or encased. Lamps shall be mounted horizontally to prevent their collecting water from condensation or possible gasket leaks.

The front panel shall be rotatable to indicate the desired direction when installed. No moving parts shall be permitted. Fiberoptics shall be protected by a black ABS plastic vacuum formed sculptured cover to eliminate the possibility of damage when installing or relamping.

The front panel of the signal section shall be colored black to minimize legibility of the arrow when not illuminated. No color at all shall appear when not illuminated regardless of sunlight intensity.

All fiberoptic, transformers and lamps shall be mounted on the door of the signal section. All screws, washers, nuts and bolts shall be corrosion-resistant stainless steel. All components shall be readily accessible when the door is opened. The only tool required for maintenance shall be a standard screwdriver.

9--Painting: All surfaces of the signal housing, door, visors, inside and out, shall be cleaned and coated with a Primer conforming to FS MIL-P-8585. The surfaces shall then be finished with three coats of infrared oven baked paint, before assembly.

First Coat: The primer shall be iron oxide backing primer and shall meet or exceed the requirements of FS TT-P-636, paragraph 4.2.3.

Second Coat: Shall be light gray exterior baking enamel and shall comply with FS TT-E-489, either #16251, #16314, or #16376 Gray.

Third Coat: Highway Yellow Enamel shall be traffic signal highway yellow exterior baking enamel and shall comply with FS TT-E-489. The color shall be No. 13538 according to Federal Standard No. 595. The inside of the visors shall be phthalic anhydride black synthetic baking enamel, with zero (0) gloss reflectance and shall meet the performance requirements of Mil-E-5557 Enamel Heating Resisting Glyceryl Phthalate Type 4, Instrument black. The housing door and the outside of the visor shall be painted Flat Black unless otherwise specified.

M.16.07--Pedestrian Signal: The materials for this work shall conform to the following requirements:

A. General: The pedestrian signal shall be one section, rectangular in shape, and shall conform to the latest edition of the MUTCD for Streets and Highways. The over-all size of the pedestrian signal, including visor, shall be approximately 510 mm wide by 405 mm high by 405 mm deep. The pedestrian signal shall be the incandescent type housed in a weather-proof and dust-tight aluminum housing, designated to display the alternating messages "Don't Walk" or "Walk." The message shall be attention-attracting and clearly legible when luminated. The letters shall have a 16 mm stroke by approximately 115 mm high. The message shall read "Don't Walk" in Portland Orange or "Walk" in Lunar White.

B. Housing: The housing shall be one piece, corrosion resistant, aluminum alloy casting. The top and bottom of the housing shall have an opening to accommodate standard 38 mm pipe brackets. Each housing shall have a terminal block with a sufficient number of terminals to accept field wires. Two integrally cast hingelugs shall be cast on one side of each housing, and two integrally cast latch-screw pads shall be cast on the other side of the housing.

C. Housing Door: The housing door of each signal shall be a one-piece, corrosion resistant, aluminum alloy casting. Two hingelugs shall be cast on the other side of each door. The door shall be attached to the housing by means of two stainless steel hinge pins. Two stainless steel hex-head, captive-latch screws shall be permanently attached to the door bosses by means of keeper washers. The door shall have a neoprene gasket, which when the door is closed, shall cause a seal against the housing, making a positive weather-proof and dust-tight seal.

D. Visor: Each signal shall be provided with an aluminum visor approximately 178 mm long which shall encompass the top and sides of the signal face. The top of the visor shall have a downward tilt of approximately 3-1/2 degrees. The center of the visor shall be divided by a horizontal baffle. The visor shall be blanked and formed and shall be not less than 1.3 mm thick and shall meet the minimum requirements of ASTM B 209.

E. Lens: The lens shall be of rigid type polyester resin having an especially high heat distortion point and excellent resistance to degradation at high temperatures. Lens thickness shall be a minimum of 4.8 mm. Lens gasket shall be molded neoprene rubber channeled to cover the entire perimeter of the edge. The gasket shall press against the frame when the door is closed to form separate dust-tight optical compartments.

F. Reflector: Reflectors shall be of one piece parabollic construction, designed to direct light from the lamp outward with maximum efficiency. The reflector shall have a flange that will form a flush fit with the gasket when the door is closed.

G. Electrical: Sockets shall be one piece molded construction and shall be fastened to the reflector. The socket shall have a "lamp grip" to prevent lamp loosening. Color coded leads of 18 gauge shall be attached to the terminal block in the signal. Lamps shall be 67 watt standard traffic signal lamps.

H. Hardware: All exposed screws and fasteners shall be stainless steel. All interscrews, fasteners and metal parts shall be stainless or non-ferrous and non-corrosible materials; or if ferrous materials are used, they shall be protected against corrosion by cadmium plating.

I. Painting: All surfaces of the signal housing, door, and visors, inside and out, shall be finished with three coats of infrared oven-baked paint before assembly.

First Coat--Primer: Shall be iron oxide baking primer and shall meet or exceed the requirements of FS TT-P-645.

Second Coat--Gray Enamel: Shall be light gray exterior baking enamel and shall comply with FS TT-E-489, #16251 or #16314 or #16376 Gray.

Third Coat--Highway Yellow Enamel: Shall be traffic signal highway yellow exterior baking enamel and shall comply with FS TT-E-489. The color shall be No. 13538 according to Federal Standard No. 595. The inside of the visors shall be according to FS TT-P-527. The color shall be lusterless black Color No. 37038 to comply with Federal Standard No. 595.

M.16.08--Pedestrian Push Button: Pedestrian push buttons shall be of substantial tamper-proof construction and shall consist of a direct push type button with a single momentary contact switch in die-cast aluminum alloy housing to meet the minimum requirements of ASTM B 85, on which shall be attached the push button advisory sign as shown on the plans.

The switch shall have snap action contacts, connected by a three-bladed beryllium copper spring, and shall be rated at 10 amperes, 125 volts. Pedestrian push buttons shall not have any levers, handles, or toggle switches externally or internally, and shall operate on 12 volts AC. The pedestrian push button shall conform in size and the required force to activate the pedestrian signals as specified in the Americans With Disabilities Act (ADA), Section 14.2.6 Crossing Controls.

The assembly shall be weatherproof and so constructed that it will be impossible to receive any electrical shock under any weather conditions. Installations within the housing shall be so designed that they can be removed as units from the housing for the purpose of inspection and maintenance. Push-button contacts shall be entirely insulated from the housing and operating buttons. The contacts shall be normally open, and shall be closed only when the push buttons are operated by pressure, restoring immediately to the normal open position when the pressure is released. The back of the housing shall be flat type to provide a rigid installation. Cable entry shall be through the back so that all wiring may be concealed with no external conduit required, except when indicated on the plans.

Painting: All surfaces of the unit shall be finished with three coats of infrared oven baked paint, before assembly.

First Coat, Primer, shall be epon oxide baking primer and shall meet and exceed one performance specification of FS TT-P-636.

Second Coat, Gray Enamel, shall be lusterless and shall comply with FS TT-E-527.

Third Coat, Yellow Enamel, shall be Federal Yellow Baking Enamel and shall comply with FS TT-E-489. The Color shall be 13538 according to Federal Standard No. 595.

M.16.09--Controllers: The materials for this work shall conform to the following requirements:

1--Pretimed Controller:

It is the purpose of this section to set forth minimum design and operating requirements for the 3 dial pre-timed expansible type controller.

Constancy of Intervals: The length of any interval portion shall not change by more than 5 percent when the voltage of the power supply varies from 95 volts to 130 volts and the ambient temperature within the cabinet housing the controller varies from -34° C to 71° C. This performance shall be obtained without the use of any heater elements.

Power: The controller and all associated equipment shall be designed for use with 120 volts 60 cycle single phase, alternating current.

Components: All components of the controller shall be designed for heavy duty. All motors, operating coils, bearings, contacts, relays, flashers, etc. shall be sufficiently large, rugged, and accessible to insure reliability and minimum maintenance. The dial contacts shall be of the leaf-spring type mounted on a molded bakelite block and equipped with terminal screws. The contact size shall be at least 6.4 mm diameter, 1.6 mm thick, and contain at least 90 percent pure silver. The contacts that handle any signal light load shall not require fine adjustment and readjustment for satisfactory and continuous operation. All such mechanisms shall be neatly and systematically arranged to make possible thorough inspection while the controller is operating in accordance with its normal functions.

Cabinet: Each controller assembly shall be completely wired and housed in a rigid metal cabinet with a suitable finish. The cabinet shall be of clean-cut design and appearance and shall be substantially constructed of aluminum. The pedestal mounted and pole mounted cabinets shall be approximately 380 mm by 490 mm by 890 mm in size or the equivalent in volume, and the base mounted cabinet shall be approximately 430 mm by 865 mm by 1220 mm in size or the equivalent volume. The cabinet shall have a main door which shall be equipped with a special CONN-1 lock and key and an auxiliary door which shall be equipped with a lock and a police key. Door hinge pins shall be of stainless steel material. Two keys shall be furnished for each lock. When closed, both doors shall fit tightly to neoprene gasketing material. The cabinet shall contain a suitably designed vent for the purpose of releasing any explosive gases which may enter the cabinet. The "T" vent (38 mm diameter) shall be mounted on the top of the cabinet, with a screen vent at the bottom of the cabinet.

A panel behind the auxiliary door shall contain the following:

1. A switch to control the change from automatic control to flashing operation and vice-versa. In the flashing position, the control unit shall not be de-energized.
2. A switch to control the change from automatic control to manual operation and vice-versa. A manual cord not less than 2 m long equipped with a rubber-covered hand switch, and permanently installed.
3. A "Main Switch" which will be used for signal shutdown. During signal shutdown, power to the controller shall be unaffected. The function of this switch can be incorporated into the flash switch by providing a three position switch (NORMAL-OFF-FLASH).

The cabinet shall contain a means of mounting the controller which will permit easy access to controller while in operation and accessibility to the components and terminals for maintenance and repair purposes. The cabinet shall be provided with necessary openings for mounting and connections and be wired to include a cable for time-clock installations with an octal 5-pin plug.

All panel wiring shall be neat and firm and the panel which shall be mounted in the rear of the cabinet shall mount the following:

1. Neutral Bus Bar, for neutral side of power supply line. This Bus Bar shall be rated for 30 amperes.
2. Terminals for conductors of signal light cable - one for each signal circuit and one or more terminals for the common conductors. This terminal bus shall be rated for 30 amperes. No pressure type terminal blocks will be accepted.
3. A one-piece 120 volt convenience outlet and lamp receptacle. A heavy duty 30-ampere screw type fuse and socket shall be mounted on the left side of the controller cabinet. The controller equipment and terminals shall be so arranged within the cabinet that they will not prevent the entrance, training and connection of the incoming conductors. All field terminals shall be suitably identified.

The cabinet shall have a hole for cable entrance into the bottom of the cabinet of at least 76 mm in diameter. There shall be an adapter for mounting the cabinet on a 100 mm pipe, provided with each cabinet.

The outgoing traffic control signal circuits shall be of the same polarity as the line side of the power supply. The grounded side of the power supply shall be grounded to the controller cabinet.

All conductors shall be provided with lugs for attachment to binding posts. Combining of conductors to one lug will not be allowed. Non-hygroscopic materials, having good insulating qualities, shall be used for all insulating purposes. All internal wiring to lamp circuits shall be #14 AWG stranded drawn copper. Wiring shall be cabled. The cable connection from the panel board to the controller shall be made by an "MS" type positive plug. A minimum of nineteen (19) signal circuits shall be provided each rated at a minimum of 15 amperes.

Leakage resistance between electrical connections or to ground shall not be less than 1 megohm. A minimum spacing of 13 mm shall be maintained between any terminal connection and any other similar connection or ground. The electrical connection from the controller to the outgoing and incoming circuits shall be made in such a manner that the controller may be replaced with a similar unit without the necessity of disconnecting and reconnecting the individual wires leading therefrom. Connector plugs shall be used that will contain sufficient contacts for proper functional operation of the controller. The controller to be supplied shall be wired complete for three (3)-dial operation. All relay jack panels shall be of the female type.

Timer: The timer of the controller shall consist of a signal switching unit with a combination interval and offset timing dial unit securely mounted and of such construction that the entire timer assembly can be swung out from the cabinet for inspection or maintenance without breaking any electrical connections or interrupting the normal operation of the controller. The timer shall be connected electrically to the panel of the controller by means of an electrical jack or plug disconnect that will permit quick removal of the complete timer assembly as a single unit when necessary.

Timer Housing: The timer shall be enclosed in a rigid metal housing with a transparent window so that all timing settings, interval, offset and total cycle length control shall be visible but not accessible when the control box door is open.

Color Sequence: It shall be possible by effecting a change in the shape of the cams operating the signal circuit contacts to obtain any signal color sequence desired. A minimum of nineteen (19) signal circuits and 16 signal color intervals shall be provided on a single cam bar.

Period Timing: All signal color interval adjustments shall be quickly made, without tools, from the front of the timer on a dial clearly marked and calibrated in percent from 0 percent to 99 percent. Any signal color interval shall be adjustable to a minimum of 2 percent in steps of 1 percent. The timing dial shall give a visual indication of the relative length of each color period at all times. The duration of each signal color interval in percent of the total time cycle shall be as indicated on the percentage dial calibration. Each timing key shall be self-locking in the timing dial.

Timing Dial Units: The controller shall be furnished with three dial units each consisting of a synchronous motor-driven timing dial together with its dial contacts and other necessary parts and shall be provided with adequate mechanical mounting and electrical jacks so that it can be removed and/or replaced quickly without the use of tools in a single operation wherein both mounting and electrical connections are made simultaneously.

Motor: A drive coil shall drive the synchronous motor at the cycle length called for by the timing gear. There shall be provided a means of positively stopping the dial motor while the local controller is resynchronizing with the master controller.

Each motor shall be of the self-starting synchronous type, such as Telechron heavy duty or disk type and shall have sufficient torque to permit its dial to operate synchronous at all outside temperatures between -34° C and 71° C. The transfer to an unused dial shall be possible within this same temperature range. The motor torque shall be sufficient to operate the timer at synchronous speed when used with a 30-second cycle and shall be sufficient to overcome any tendency to slow up due to shocks or vibration, thereby providing synchronous operation between the limits of 95-130 volts.

Timing Dial: The timing dial shall support the timing keys over their entire length and shall contain 100 precision die-cast slots for this purpose. All timing keys for a given function shall be identical and each key having specialized function shall be appropriately colored to provide a visual indication of such function. All contacts operated by the various timing keys shall have helical springs controlling both movement and contact pressure so that flexible arm adjustments are eliminated.

It shall be possible to keep the timing dials, not controlling the sequence at any given time, running continuously. This will allow an offset relationship to be maintained between on interconnected (hard wire) intersections.

Cycle Change: Each controller shall be furnished with a cycle gear as specified on the plans, installed in the timing dial unit and gears for 60-70-80-90-100 seconds shall be furnished and stored in the controller cabinet. The range of possible gear change shall be from 30 to 120 seconds in 5-second steps with gears other than those normally supplied with the controller. Gears within the 30- to 120-second range shall be available from the controller manufacturer. It shall be possible to change the total cycle on the street easily and quickly without the use of tools. The action of changing gears shall automatically indicate the total cycle value in use on a scale visible from the front of the timer. The mesh between the motor pinion and any time cycle gear shall be indexed automatically so as to result in proper mesh for free-running gearing and to avoid any possibility of binding which might affect synchronous operation of the driving motor.

Manual Offset: Due to the synchronous motor drive of the timing dial, it shall be possible to obtain coordination between respective dials at adjacent but non-interconnected intersections by means of a simple motor synchronizing switch mounted on the front of the dial unit where it will be tamper-proof by virtue of the timer housing herein before specified.

Automatic Offset: The timing dial unit shall be equipped with means by which it may be automatically resynchronized by remote control when connected to a master controller. The dial unit shall be furnished complete for triple offset. The controller shall be so wired that a choice of 3 different offsets on the dial may be remotely selected over a total of not more than 3 interconnecting offset conductors.

All offset adjustments shall be made without tools on the same timing dial as the signal color period adjustment but calibrated separately in steps of 1 percent from 0 percent to 99 percent in the reverse direction from the color period timing. Each offset key shall be clearly identifiable. It shall only be necessary to move one offset key to change an offset setting and each key shall be self-locking in the timing dial.

Signal Switching Unit: The signal switching unit shall provide wiring for a minimum of 19 signal light circuits. Each of the signal contacts shall open and close independently of each other so that the flexibility of their operation shall not be limited. The movable signal circuit contact arms shall be of hardened steel or other suitable rigid material so that they shall be wear-resistant and shall not flex, bend or take a permanent set in operation.

All make and break contact tips, whether movable or fixed, shall give contact faces not less than 8 mm in diameter, 3.2 mm thick and shall be made of at least 90% pure silver and 10% cadmium oxide, by mass, or superior alternate material. The contacts shall be capable of breaking a current of 15 amperes, 120 volts, 60 cycle alternating current, one million (1,000,000) times without excessive pitting or burning when operated 120 times an hour. All signal contacts shall be readily accessible and easily inspected. The operation of moving or replacing movable contacts shall not change the

contact pressure adjustment and shall be accomplished easily and quickly with the use of simple tools. The stationary contacts shall be replaced by the use of simple tools.

The ratchet motor shall be capable of effectively changing the position of the cams with equal efficiency up to and including the capacity of the cam shaft.

Panel Board: A molded or pressed panel shall be provided on which all signal terminals (plus and common), relays, flashing mechanism and switches, flash combination terminals, terminals for field addition of manual switch accessory and terminals to allow all dial motors to run under non-interconnected operation shall be mounted.

Flasher: A Jack-mounted, unit type motor-driven or solid state flasher complete with radio interference suppressor shall be furnished to permit flashing operation of the signals when the timer is disconnected and removed from the controller. This shall be a two-circuit flasher rated at approximately 20 amperes.

Manual and Remote Switches in the Auxiliary Door: Manual switching flexibility shall be provided to permit the following operations:

Flashing Operation: The manual and remote flash switch or relays shall provide flashing indications for four (4) independent circuits so that the controller may be used to control two-phase vehicle movements and four-phase vehicle movements (in doing so, power to dial motors shall be unaffected). In addition flash combination terminals shall allow the selection of flashing either yellow or red on the cross streets.

Manual Operation: The Auto-Hand switch shall provide means whereby manual timing of the signals may be obtained with a separate momentary contact hand switch. Operation of the timer by manual control shall provide the same color sequence as on automatic operation and no momentary undesirable indications shall show. Manual control shall be possible with the main door of the cabinet door closed.

Dial Selector Switch: The manual dial selector switch in the main cabinet shall provide for the selection of dials by:

1. Remote Control
2. Dial 1
3. Dial 2
4. Dial 3
5. Clock Position

Relay Wiring Provisions:

Jack-mounted relays shall be provided for:

1. Flashing four-signal circuits
2. Two dial transfer relays

Wires and Insulation:

Except where soldered, all wires shall be provided with lugs or other approved terminal fittings for attachment to binding posts.

All wiring between various parts of the control box shall be a minimum of #18 AWG type TFF with 2/64--105 C. thermoplastic insulation or approved equivalent. Where cable wire must be clamped to the walls of the control box to prevent undue wear or flexing of the wires, such clamps shall be of suitable non-conducting material, such as rubber insulated metal straps.

The wiring from the timer jack connection to the terminal board shall be covered with a braided stocking or other method approved by the Engineer. The individual signal circuit wiring shall have a current carrying capacity of not less than 15 amperes.

Actuated Pedestrian Phase: The actuated pedestrian phase shall be obtained by effecting changes on the signal circuit cams and the dial drum in conjunction with auxiliary equipment which shall be external to the controller. Other than these changes, the controller shall be standard in all respects.

When an actuated pedestrian phase is called for, the pedestrian timing shall be taken out of two phases with no change in the cycle length.

The pedestrian clearance interval shall be flashing "DON'T WALK."

Painting: All outside surfaces of the cabinet and door shall be finished with 3 coats of infrared oven-baked paint before assembly.

First Coat--Primer: Shall be epon oxide baking primer and shall meet or exceed FS TT-P-636.

Second and Third Coats--Aluminum: The second and third coats will be aluminum paint in conformance with the requirements of Article M.07.12.

Manuals: The contractor shall secure from the manufacturer a comprehensive service controller.

Six (6) paper prints of the cabinet wiring diagram the entire field connection chart shall be left blank.

A comprehensive parts list, detailing all replaceable components as to manufacturer part number, and commercially available part number, and manufacturer's net price each, shall be provided. This list may be referenced from the drawings supplied with the equipment.

Guarantee: The contractor shall secure from the manufacturer a guarantee for the equipment for a period of twelve (12) months, which time shall commence from the date of delivery. If a unit is found to be defective during this twelve month period, it will be the responsibility of the contractor to assume the cost of shipping the controller to and from the factory, supplying parts and making repairs at no cost to the State of Connecticut.

M.16.10--Flasher Cabinet:

1--Cabinet: All equipment shall be housed within an aluminum or aluminum alloy weatherproof cabinet. If not cast aluminum, the seams shall be at least 3.2 mm in thickness and the seams shall be continuously welded. The cabinet shall be clean cut in design with a door which shall encompass substantially the full area of the front of the cabinet. When closed, the door shall fit tightly to neoprene gasket material. The door shall be equipped with a CONN-1 lock and shall have stainless steel hinge pins. Two keys shall be provided with each cabinet. The cabinet shall have a screened "T" vent on top and a screened cut out of the bottom for ventilation. The size of the cabinet shall conform to the following dimensions:

Depth	Width	Height
305-355 mm	305-405 mm	355-635 mm

A panel shall be mounted in the back of the cabinet on which shall be mounted the following items:

- (a) Circuit Breaker - 15 Amp
- (b) Duplex Convenience Outlet
- (c) Lamp Receptacle
- (d) Terminal Block - Heavy-duty, screw type, to accommodate lugs for wire size #16 to #14 AWG.
- (e) Neutral Buss Bar - Rated for 30 Amps.
- (f) Radio interference filter - Rated for 30 Amps, 120 VAC, 60 HZ, and shall meet the standards of the Underwriter's Laboratory and the Radio and Television Manufacturer's, Association.
- (g) Solid-State flasher mounting rack and socket.

2--Flasher: The flasher shall conform to the latest NEMA Publication, part 8, with the following additions:

The flasher output shall be from optically isolated solid-state relays.

The solid-state relay shall switch off with an input between 3 and 32 volts D.C.

The flasher shall have an L.E.D. indicator connected to each output for visual reference.

M.16.11--Pressure-Sensitive Vehicle Detector: Detectors, in combination with control equipment, shall be capable of actuation by a vehicle crossing the detector at any speed up to 97 km/h, under normal conditions.

Detectors shall be mounted in a steel frame or housing, having a splicing chamber. The chamber shall be provided with a weatherproof door or cap. The chamber shall be placed in such a manner that the chamber door or cap can be opened without disturbing the pavement. All necessary anchoring and installation accessories shall be supplied with each detector. Provision for draining the splice box shall be provided.

The detector housing shall be so constructed that the contact element can be inserted, without disturbing the installation in the pavement.

The control element of the detectors shall be of one-piece construction and shall be so designed that no metal screws or bolts shall be exposed to traffic wear. The surfaces of the detector units, which are exposed to traffic, shall consist of rubber 25 mm thick. The rubber shall be specially compounded for the duty it is to perform and shall be securely vulcanized to metal base plates of the contact element. Bolts which hold the contact element in the housing shall be well graphited before installation and shall not extend above the pavement surface. These bolts shall be stainless steel or approved equal. The rubber surface exposed to traffic shall not be less than 250 mm in width, and the length shall be approximately the length of the detector. The surface shall not be higher than the housing holding it, and in no case shall the surface be lower than 3.2 mm below the rim.

The electrical contact area assembly shall be moisture-proof, and provision shall be made for making a waterproof splice between the contact area and the conductor.

Detectors shall be so constructed that they will operate on a normally open electrical circuit and will make an electrical contact whenever any motor vehicle passes over the detector.

M.16.12--Loop Vehicle Detector and Sawcut: The materials for this work shall conform to the following requirements:

1. Loop Vehicle Detector:

A. Functional Requirements: The loop detector shall be an electronic device, capable of detecting the presence of a moving or parked vehicle; and the detection shall be accomplished by the presence of a parked or moving vehicle over a wire loop embedded in the roadway. The detector unit shall be of the "self-tuning type." The detector shall be capable of tuning to an inductance range of 50-1000 micro Henries. It shall be possible to select a minimum of the following modes of operation, which shall function as follows.

(1) Mode 1 (Short Detection): The detector sensing unit shall detect a vehicle as slow as 0.2 km/h entering the loop. If a vehicle stops over a portion of the loop such as waiting for a left turn, the remaining portion of the loop shall detect additional vehicles passing over the unoccupied portion of the loop. The time for the remaining portion of the loop to become capable of detecting additional vehicles shall be no longer than the minimum time it takes for the next vehicle to pass over the loop.

(2) Mode 2 (Long Detection): The detector sensing unit shall detect a vehicle as slow as 0.2 km/h entering the loop. When a vehicle remains over the loop or a portion thereof, the detector sensing unit shall cause detection to persist up to at least 10 minutes. After this period any vehicle passing over the unoccupied portion of the loop shall be detected.

(3) Delayed Output Detection: The detector sensing unit shall provide digital type timing, with capabilities of 0-30 seconds delay. The sensing unit shall provide the delay except when the controller is in the green interval of the associated phase. During this green, the delay set into the detector will be omitted.

The sensing unit may also be used as a standard vehicle detector by leaving the selector switch in "off" position. A standard detector wire harness with a type "MS" plug is to be used.

B. Electrical Requirements: The detector sensing unit shall operate on 115 volts, 60 cycles A.C. and shall draw not more than 15 watts.

The unit shall contain an integral regulated power supply which will operate independent of line voltage variations between 100 and 135. The power supply shall be regulated by Zener reference and series regulation and shall be fused.

The detector shall operate properly at all temperatures between -34° C and 66° C. An automatic frequency control feature and automatic equalization feature shall be included in the detector to compensate for long-term drift due to environmental changes.

All transistors and integrated circuits shall be plug-in type for serviceability. The detector relay driver shall employ a silicon transistor.

C. Mechanical Requirements: The detector shall be housed in a durable finished fabricated sheet aluminum case. No special tools shall be required for removal of the cover. Removal of the cover shall provide access to the entire circuit and all components while the unit is connected and operating. The electrical connections of both the incoming and outgoing circuits shall be made by means of suitable multi-pin plug. The entire unit shall be replaced with a similar unit without the necessity of disconnecting the reconnecting individual wires leading therefrom. The plug receptacle shall be attached to one end of a connecting cable at least 1.2 m long. The cable shall be color coded and each wire shall be fitted with a spade type lug for easy attachment to the controller terminal block.

A switch mounted on the front of the detector unit shall be provided for selecting the mode of operation to be in effect. Also mounted on the front of the detector will be an indicator light which will register vehicle actuations.

When 2 channel loop amplifiers are used, each channel shall have a connecting plug with all wires in each of the harnesses connected so that it may be replaced with two single channel amplifiers.

The loop identification tag shall be 80 mm x 130 mm, 0.25 mm thick plastic.

2. Sawcut:

A. #14 AWG type THWN, or THHN stranded wire rated at 600 volts shall conform to the appropriate articles of the NEC. The wire shall be encased in flexible vinyl plastic or polyethylene tubing having a 4.8 mm ID, a minimum of 0.8 mm wall and a 6.4 mm OD. The tubing shall be capable of resisting deterioration from oils and solvents, have a smooth bore and be highly abrasion resistant. The loop detector wire shall conform in all respects to I.M.S.A. Specification.

B. The plastic compound shall be liquid with a synthetic resin base with a specific gravity of approximately 1.7. It shall have a minimum viscosity of 3.5 Pa-s at 25° C and a maximum viscosity of 65 Pa-s at -4° C. The plastic compound shall be polymerized (cured) by the addition of a specific reaction initiator (hardener). Sufficient hardener (usually a liquid organic peroxide) shall be used to cure the plastic compound in approximately 30 minutes at 21° C. It shall be possible to cure the compound at temperatures below freezing. The plastic compound, after curing shall have sufficient strength and resiliency to withstand stresses set up by vibration and expansion and contraction due to temperature changes. The compound shall also be resistant to most chemicals and solvents, including most salts, acids and hydrocarbons.

The plastic compound shall conform to the following testing requirements: ASTM D-149, ASTM D-495, ASTM D-638, ASTM D-1167, and ASTM D-192.

A one part urethane elastomeric compound may be substituted for the plastic compound.

The elastomeric compound shall not require curing by the addition of a reaction initiator. The uncured elastomeric compound shall have a viscosity of 5 Pa-s to 35 Pa-s. The elastomeric compound shall be viscous enough not to flow out

of a sawcut in a sloped road, but still fully encapsulate all wires in the sawcut. The elastomeric compound shall form a surface skin within 60 minutes at 24° C. The elastomeric compound shall be packaged in a standard liter caulking cartridge with the nozzle designed for insertion in a sawcut 3 mm to 6.4 mm in width and 38 to 64 mm in depth. The compound shall also be available in 19 L pails to be used with a pneumatic pump application system. After hardening, the elastomeric compound shall remain flexible and exhibit no visible shrinkage. The elastomeric compound shall have sufficient strength and resiliency to withstand normal stresses such as: vibration, expansion and contraction; and to resist most chemicals and vehicular fluids such as: motor oil, gasoline, brake fluids, and antifreeze solution.

The elastomeric compound shall conform to the following testing requirements: ASTM D-1875, ASTM D-2834, ASTM D-1640, ASTM D-2340, and ASTM D-412.

C. The flexible plastic conduit shall conform to the requirements of ASTM D-2737.

M.16.13--Magnetic Vehicle Detector: The materials for this work shall conform to the following requirements:

1--The magnetic elements shall be housed in a nonferrous case, and they shall be waterproofed by the vacuum impregnation process. The detector shall have an internal resistance not to exceed 3500 ohms and shall be designed for operation with a magnetic detector solid state amplifier. One end of the housing shall be threaded to accommodate a conduit. The assembled detector shall not be rendered inoperative or continuously operated by parked cars or other fixed iron objects such as road reinforcement and water or gas pipes which may be within its zone of influence.

The single lane magnetic detector shall consist of two main assemblies, the detector coil unit and the pavement box. The coil unit shall be assembled with two iron-covered coils connected in series and molded in a solid block of insulating material. The pavement box shall be a heavy duty aluminum casting with dimensions of approximately 230 mm X 200 mm X 150 mm. Flanges threaded for 32 mm conduit will be provided on two sides and the bottom. The box shall have a removable cover, fastened with stainless steel bolts.

The concrete that is used in the installation of the pavement box shall be a fast-setting high-strength type. The concrete shall be hard enough in one hour to allow traffic to pass over it. It shall be a type acceptable to the Engineer.

The proper operation of the magnetic detector shall not be affected by extreme temperature or humidity.

2--The amplifier unit shall be fully transistorized utilizing open type printed wiring panels and high-grade silicon transistors. The printed circuits shall be of extra heavy (29 g or better) copper.

All circuits shall be designed to provide stable operation within an ambient temperature range of -34° C to 82° C.

The magnetic detector amplifier shall be designed for operation on a nominal 120-volt 60-cycle, single-phase A.C. supply. Nominal power consumption shall not exceed 2 watts.

The unit shall be housed in a durable finished fabricated sheet aluminum case. Removal of the unit from its case shall require the use of simple tools. When the unit is removed from the case, it shall be possible to gain access to the printed circuit panel and components.

Electrical connections of both the incoming and outgoing circuits shall be made by means of a suitable plug.

The unit shall be replaceable with a similar unit without the necessity of disconnecting or reconnecting individual wires leading therefrom.

The plug shall be of protected male construction and rigidly fixed to the front of the unit.

The mating plug receptacle shall be attached to one end of a connecting cable at least 610 mm long. The other end of the connecting cable shall have color-coded leads, each of which shall be fitted with a spade lug for easy attachment to terminal blocks.

The sensitivity of the unit shall be dial adjustable, and continuous over the full range. On the front of the unit adjacent to the adjustment dial and connector plug there shall be mounted two jacks for the purpose of checking the proper adjustment of the sensitivity knob.

The registration of overlapping pulses from two detector amplifier units shall be ensured by the use of normally open and normally closed contacts provided on the output relay. Any contact that opens or closes in response to vehicle actuations shall be capable of making, breaking, and carrying 3 amperes at 120 volts A.C. The front panel of the detector amplifier unit shall contain a "Detection Indicator Lamp" that will pulse as each actuation is registered.

M.16.14--Control Cable: The materials for this work shall conform to the following requirements:

1--General: All cable and wiring to be used on this project shall conform to the appropriate articles of the NEC.

2--Conductors: Traffic control conductors shall be designed for 600 volts, AC and shall be of solid copper, having conductivity in accordance with IMSA and NEC standards.

The size of the conductors shall be as indicated on the plans.

3--Cable: Traffic control cable shall be multi-conductor and polyvinyl chloride or polyethylene sheathed. Insulation shall be polyethylene. Sheathed insulation and color coding shall conform in all respect to IMSA Specification No. 19-1 or No. 20-1, whichever is applicable. The Contractor shall furnish a manufacturer's warranty that the cable furnished is resistant to damage and deterioration by sustained contact with greases or oil.

Magnetic and loop detector lead-in cable shall be two conductor cable using stranded tinned copper conductors, color-coded polyethylene insulation, an aluminum backed mylar shield with a stranded tinned copper drain wire over the twisted pair, a black polyethylene outer jacket, and is listed under U.L. Style 2106. The loop lead-in cable shall conform to I.M.S.A. specification 50.2.

4--Number of Conductors: Sufficient signal light conductors shall be provided to perform the functional operation of the signal system. The number of conductors utilized shall be as indicated on the plans or as directed by the Engineer. Power supply cable between the sources of power and the controller shall consist of 600 volt, 2 conductor stranded wire of the size and type called for on the plans.

The number of conductors set forth in the plans is the minimum number that the Contractor shall supply. The Contractor may supply more than the specified number of conductors at his own expense.

5--Cable Closure: The cable closure shall be made of Neoprene construction. Internal brackets shall be aluminum and external parts shall be stainless steel or aluminum. The cable closure shall be provided with four (4) entrances, each of which will accommodate cable with a diameter of 15 mm to 25 mm. The size of the closure shall be as shown on the typical plan sheet. The cable closure shall be provided with the minimum number of terminal blocks shown on the plans. Each terminal block shall be provided with 12 brass studs, nuts, and 24 washers. The block shall be a solid injection molded ABS (acrylonitrile butadiene styrene) that has a low moisture absorption rate. The terminal blocks shall be approximately 83 mm W X 38 mm H X 13 mm thick and be provided with mounting studs.

M.16.15--Messenger and Span Wire: The materials for this work shall conform to the following requirements:

1--Messenger wire shall be a double galvanized, seven-strand steel wire cable not less than 4.8 mm in diameter and 10.7 kN breaking strength, utilities grade.

2--Span wire shall be double galvanized seven-strand steel wire cable not less than 9.5 mm in diameter and 50 kN breaking strength, utilities grade.

3--All hardware accessories as shown on the plans used in span wire or messenger mounting shall be of high strength, double galvanized, first quality materials.

M.16.16--Polyvinyl Chloride Conduit: The polyvinyl chloride conduit shall be schedule 40 grade, shall comply with all requirements of the Underwriter's Laboratories standards and shall be stamped UL approved.

M.16.17--Illuminated Signs: The sign shall be a blank-out type which shall display the type of message specified, through the use of light-transmitting fiber optic bundles.

The legend displayed shall be in accordance with the plans. Shop drawings of the front panel showing the lettering, and the type of visor shall be submitted for approval. The message shall be clearly legible under any lighting condition without the need for a visor or hood and attract attention at full intensity, anywhere within a 20 degree cone centered about the optical axis. The message shall be blank when not illuminated.

The non-lensed bundles shall be fully bifurcated for burnout protection with 8 lamps. The diameter of the fiber bundles shall be as shown on the plans. There shall be a separate fiber bundle, from each of the light sources, displayed in a row along the bottom of the sign to indicate lamp outage. All fiber optics, transformers and lamps shall be mounted on the hinged door of the unit. The blank-out sign assembly shall display the message in "Lunar White." Type "ENL" quartz-halogen lamps shall be used to illuminate the message. These lamps shall operate between 10.5 and 10.8 volts via the supplied step-down transformers. Average lamp life shall be not less than 8,000 hours. The lamps shall be mounted horizontally. "Overhead Illuminated 'Stop Ahead' Signs" shall have an 8 lamp minimum.

The electrical connection shall be provided by an internal barrier-type strip for connecting the electrical service wires. There shall be a 15 amp A.C. snap switch mounted in a utility box on the inside of the sign, enabling the sign to be shut off during maintenance. Power consumption for the message shall be less than 500 Watts.

A weatherproof housing of the dimensions specified on the plans shall be provided to enclose the fiber optic module assembly with bifurcated output fiber bundles, color filters, light sources and transformers. The sign housing frame shall be manufactured from extruded aluminum, 6061-T6, ASTM B-221. This assembly shall be provided with a hinged access door. The hinge shall be stainless steel piano type hinge mounted on the left side of the door. All external hardware shall be stainless steel, internal hardware shall be corrosion resistant. The housing shall have a minimum of four 25 mm diameter drainage holes. The entire front face of the sign shall be protected by a 3.2 mm thick sheet of clear polycarbonate mounted in the door frame. The housing shall be Federal Yellow according to Federal Standard 595 Color No. 13538 and the aluminum front panel shall be flat black according to Federal Standard 595 Color No. 37031 unless otherwise specified on the plans. The complete sign assembly shall not have a mass of more than 68 kg.

The legend displayed for a "Overhead Illuminated 'Stop Ahead' Sign" shall consist of letters 305 mm high and approximately 230 mm wide formed by fiber optic bundles spaced approximately 38 mm apart. The sign shall be supplied completely assembled and ready to be checked out.